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(54) **Device for the thermal overload protection of an electric motor and related method**

(57)   The present invention relates to a device for the thermal overload protection of an electric motor, comprising acquisition and processing means 101 which acquire from suitable detection sensors analog signals 1 indicating the currents supplying the motor and calculate corresponding digital signals 2; processing means 102 which, depending on the input digital signals 2, calculate the status variables of a thermal model of the motor; a control unit 103 which compares at least one of said status variables received at the input with a defined threshold value and, if it exceeds the threshold, sends a tripping signal to interruption means in order to interrupt the power supply of the motor.
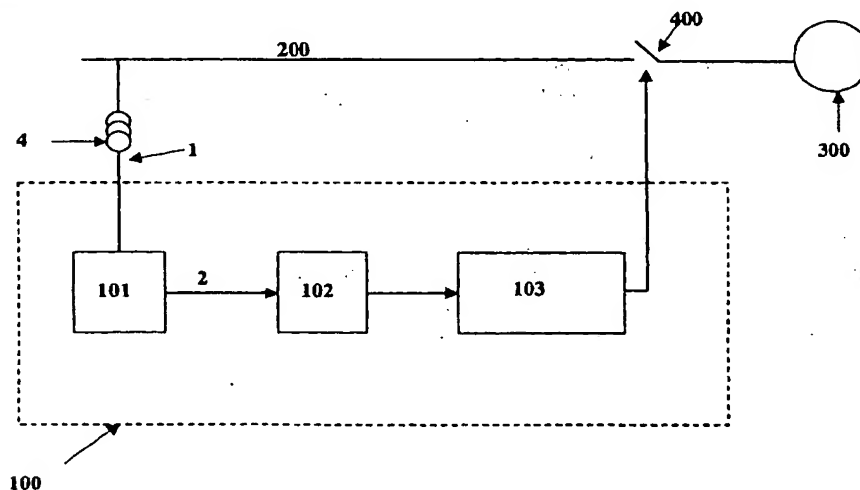
FIG. 1

EP 0 999 629 A1

Description

[0001]   The present invention relates to a device for the thermal overload protection of an electric motor and related method.

[0002]   More particularly, the device according to the present invention, through the use of a suitable mathematical model, allows to simulate the thermal behaviour of the motor in relation to the currents supplying said motor and to detect thermal overload conditions, said device differing from the known art for the high degree of precision the repeatability of its operation and its flexibility during practical use.

[0003]   The device according to the invention is particularly suitable for use in low-voltage electric motors and will be described hereinafter with reference to this application, without thereby limiting its applicational scope in any way.

[0004]   As is known, thermal overload protection devices for electric motors, and for low voltage motors in particular, are used to monitor how much current above the rating plate value has fed a motor, for how long and starting from which initial conditions of the motor. In principles, the higher the power supply current, the shorter the time for which the motor is able to withstand the overload. When the overload condition reaches potentially dangerous values for the correct operation of the motor, the protection device intervenes, interrupting the power supply.

[0005]   At present this type of protection may be provided by means of bimetallic relays, the main drawback of which consists in the extreme sensitivity to the temperature outside the motor. In fact, on account of this sensitivity, bimetallic relays cause untimely tripping of the protection system, in particular when the motor is started up again; moreover, the behaviour of the device in terms of repeatibility of operation is extremely variable.

[0006]   The use of microprocessor-based electronic relays as devices for thermal overload protection is also known; an example of this type of devices is provided by US patent No. 4,547,826. According to the solution described in this patent, in order to calculate the operating temperatures of the motor and determine tripping of the protection system, a thermal model is used, the coefficients of said model being obtained by means of electric circuits which are equivalent to the thermal behaviour of the motor. In particular, in these circuits, values which are equivalent to the parameters which characterize the physical behaviour of the motor, such as equivalent thermal masses, equivalent thermal resistances, etc., are used. This involves the need of identifying these physical parameters for each specific motor to be protected and results in lack of flexibility of the protection device and unsuitability thereof for operation in those cases where there is no information on the physical parameters of the motor, but only information on the rated values of the currents involved.

[0007]   The main task of the present invention is that of providing a device for the thermal overload protection of an electric motor which allows the thermal behaviour of the motor to be simulated in a precise and reliable manner, independently of the specific parameters of each individual motor, said device distinguishing itself from the devices of known type for the high degree of flexibility during use.

[0008]   As a part of this task, an object of the present invention is that of providing a device for the thermal overload protection of an electric motor operation of which is independent of external factors and allows untimely tripping of the protection system to be avoided.

[0009]   A further but not the last object of the present invention is to provide a device for the thermal overload protection of an electric motor that is highly reliable and relatively easy to manufacture at competitive costs.

[0010]   This task, as well as these and other objects which will emerge more clearly hereinafter are achieved by a device for the thermal overload protection of an electric motor connected to a power supply line, said line being provided with sensors for detecting the currents supplying the motor and means for interrupting said currents, characterized in that it comprises:

- acquisition and processing means 101 which acquire in input, from said detection sensors, analog signals 1 indicating the supply currents of the motor and calculate corresponding digital signals 2;

- processing means 102 which, depending on said input digital signals 2, calculate the status variables of a thermal model of the motor, said thermal model being based on status equations, the coefficients and initial cold values of the status variables of which are predetermined by means of:

  - definition of the tripping times of the protection system according to the class of motor and its rated supply current;
  - definition of a minimum current which determines tripping of the protection system and definition of the corresponding threshold values of the status variables;
  - calculation of the coefficients of the status equations and initial values of the status variables on the basis of the tripping times and the defined threshold values;

- a control unit 103 which compares at least one of said status variables received at its input with a defined threshold

value and, if it exceeds the threshold, sends a tripping signal to the interruption means in order to interrupt the power supply of the motor. The device according to the invention, by means of the introduction of the thermal model thus conceived, is able to simulate perfectly the thermal behaviour of the motor and to carry out thermal overload protection operations which are effective, precise and repeatable; in particular, it is able to perform the function of protection of low-voltage electric motors in accordance with that laid down by the international standard IEC 947-4-1.

[0011] The above mentioned task, as well as the objects mentioned above and others as well, are also achieved by a method for the thermal overload protection of an electric motor connected to a power supply line, said line being provided with sensors for detecting the currents supplying the motor and means for interrupting said currents, characterized in that it comprises the following steps:

a) acquiring, from said sensors, signals indicating the supply currents of the motor and calculating digital signals corresponding to said analog signals;

b) calculating the status variables of a thermal model of the motor using said digital signals, the thermal model being based on status equations, the coefficients and initial cold values of said variables of which are predetermined in the following manner:

- definition of the tripping times of the protection system according to the class of motor and its rated supply current;
- definition of a minimum current which determines tripping of the protection system and definition of the corresponding threshold values of the status variables;
- calculation of the coefficients of the status equations and initial values of the status variables on the basis of the tripping times and the defined threshold values;

c) comparing at least one of said status variables with a defined threshold value and, if it exceeds said threshold, sending a tripping signal to the interruption means in order to interrupt the power supply of the motor.

[0012] Further characteristics and advantages of the invention will emerge more clearly from the description of preferred, but not exclusive embodiments of the device according to the invention, illustrated by way of a non-limiting example in the accompanying drawings, in which:

- Figure 1 shows an overall block diagram of the device according to the invention;
- Figure 2 shows a detailed block diagram of the device according to the invention;
- Figure 3 shows a block diagram of the processing means used in the device according to the invention.

[0013] With reference to Figure 1, an electric motor 300 is connected to a power supply line 200; the line 200 is provided with suitable current detection sensors 4, for example current transformers, which detect the supply currents of the motor indicated in their entirety by the reference number 1, and means 400 for interrupting said currents.

[0014] Tripping of the interruption means 400, consisting for example of a contactor, is determined by a command signal imparted by a protection device 100 using the methods which will be described in detail in following.

[0015] The protection device 100 according to the invention comprises acquisition and processing means 101 which receive at their input, from the sensors 4, analog signals indicating the supply currents 1 of the motor and which output to processing means 102 corresponding digital signals 2. Advantageously, as illustrated in Figure 2, the supply energy provided by the current transformers is stored in a power supply unit 19; in this way a quantity of energy is saved, said energy being able to be used for automatic supplying, if necessary, of the device at times when the motor power supply is interrupted; for example, this power supply unit may consist of one or more capacitors.

[0016] Depending on the input digital signals 2, the processing means 102 calculate the status variables of a thermal model of the motor, using the methods which will be described in detail hereinafter. In particular, the signals indicating the value of at least one of said status variables are provided to a control unit 103 which compares them with a predetermined threshold value; if the values calculated exceed the threshold, the unit 103 sends a tripping signal to the means 400 in order to interrupt the motor power supply.

[0017] As illustrated in detail in Figure 2, the acquisition and processing means 101 comprise conditioning means 5 which condition the input signals 1 so as to provide them with a correct level for input to converter means 6; these converter means 6, which consist for example of known A/D converters, suitably sample the signals received and convert them from analog to digital signals. In the embodiment of the device according to the invention, the analog signals are sampled at a periodic frequency F_s, ranging preferably between 150 Hz and 2 kHz.

[0018] The digital signals thus obtained are then input to first calculating means 8 and to second calculating means 7.

[0019] The first calculating means 8 and the second calculating means 7 calculate, for each supply current, signals indicating, respectively, the square of the root mean square value of the current $(I_{RMS})^2$ and the square of the peak value$(I_p)^2$. The values $(I_{RMS})^2$ thus obtained are sent to first selection means 9 which select the highest value of $(I_{RMS})^2$; in turn, the peak values $(I_p)^2$ are sent to selection and compensation means 10.

[0020] The means 10 suitably compensate the input peak values $(I_p)^2$, in order to take account of any saturation of the current transformers, and select the highest value of $(I_p)^2$. Generally saturation of the current transformers occurs for values of $I > I_{sat}$, where typically $I_{sat} = 6I_n$ and In is the rated current of the current transformers used.

[0021] The two values thus selected are provided to second selection means 11; said means 11 send to the processing means 102 the signal indicating the highest value of $(I_{RMS})^2$ when $(I_{RMS})^2 < (I_{lim})$, I_{lim} being a predefined limit value, or the signal indicating the highest value of $(I_p)^2$ when $(I_{RMS})^2 > (I_{lim})$.

[0022] In a preferred embodiment of the device according to the invention the predetermined limit (I_{lim}) is equal to $6I_n$; in an equivalent manner, other limits could be defined, however, according to applicational requirements.

[0023] The selected signal, indicated in Figures 1 and 2 by the reference number 2, is then sent to the processing means 102 for calculation of the status variables of a thermal model of the motor, the status equations of which simulate, in particular, the temperature progression of the copper T_{cu} and iron T_{fe} in the motor. Preferably, the processing means 102 comprise a programmable memory selected from the group comprising: EPROM (Erasable Programmable Read-Only-Memory), EEPROM (Electrically Erasable Programmable Read-Only-Memory), flash memories, and PROM (Programmable Read-Only-Memory).

[0024] In the device according to the invention, the thermal model of the motor, during the heating transient, is based on the following difference equations with constant coefficients:

$$Tcu(t+1) = A \times Tcu(t) + B \times Tfe(t) + K \times I^2$$
$$Tfe(t+1) = C \times Tcu(t) + D \times Tfe(t) + H \times I^2 \qquad \textbf{(1)}$$

where A, B, C, D, K, H, are multiplicative coefficients, T_{cu} e T_{fe} are the status variables of the model and I^2 is the selected digital signal 2, indicating the supply currents of the motor.

[0025] In particular, in a preferred embodiment of the device according to the invention, the thermal model is calculated assuming that the coefficient H is zero; alternatively the value of H could be calculated in a manner which is entirely similar to that used for the other coefficients and which will be described hereinafter.

[0026] The two difference status equations are calculated with calculation frequencies $(F_{S1}, F_{S2}) > Fs$ where Fs is not a submultiple of F_{S1}, F_{S2}; advantageously, this solution allows the problems of aliasing to be avoided.

[0027] The processing means 102 therefore output signals indicating, respectively, temperatures of the copper T_{cu} and iron T_{fe} of the motor. In the embodiment of the device according to the invention, the signal indicating the temperature of the copper T_{cu}, is sent to comparator means 14 and is compared here with a predetermined threshold value; alternatively, and in an entirely equivalent manner, both the signals indicating the temperatures, as well as the signal for iron T_{fe} alone, could be sent to the comparison means.

[0028] In particular, this threshold value is predetermined in accordance with the formula $T_{sgl} = \beta(Imin)^2$ where β is a coefficient which has the function of relating the rated value of the current to the rated value of T_{cu}, which is the operating temperature, and I_{min} is a minimum current value which is fixed by the designer on the basis of international specifications; for example, this value may range between 1.05 and $1.2I_1$ where I_1 is the rated supply current of the motor. The rated value of T_{cu}, as well as that of T_{fe}, are values which are obtained when the supply current is $= I_1$ and are values which are known a priori.

[0029] If the calculated value of T_{cu} exceeds the predefined threshold T_{sgl} which is dependent on the number of phases of the motor which are supplied, but is the same for all the classes of protection, the means 14 send an alarm signal to command means 15 which in turn send a tripping signal 16 to the interruption means 400. This thus results in tripping of the protection device and interruption of the motor power supply owing to a thermal overload condition which is present.

[0030] Advantageously, in the device according to the invention, the coefficients A, B, C, D and K which appear in the previous equations, as well as the initial values of T_{0cu} and T_{0fe} for the "cold" transient, are calculated a priori in a specific manner for each class of overload protection and recorded in tables, using the following method.

[0031] For each class of protection, tripping times are fixed in the following situations:

-    time t_6 for the cold transient, with current equal to $7.2I_1$;

- time t_3 for the hot transient, with current equal to $3I_1$;
- time t_2 for the hot transient, with current equal to $1.5I_1$;
- time t_1 for the hot transient, with current equal to $1.2I_1$.

[0032] In particular, the classes of protection are defined in accordance with that laid down by the international standard IEC 947-4-1.

[0033] The continuous-time equivalent of the system (1), i.e. the following system, is then considered:

$$\frac{dTcu(t)}{dt} = a \times Tcu(t) + b \times Tfe(t) + k \times I^2$$

$$\frac{dTfe(t)}{dt} = c \times Tcu(t) + d \times Tfe(t)$$

(2)

where for example the parameters a,b,c,d and k are linked to the parameters A,B,C,D and K which appear in (1), by the relations:

$$\begin{cases} A = 1 - a \times \Delta t_1 \\ B = b \times \Delta t_1 \\ K = k \times \Delta t_1 \\ C = c \times \Delta t_2 \\ D = 1 - d \times \Delta t_2 \end{cases}$$

(3)

in which Δt_1 and Δt_2 are the calculating steps used for the equations (1). The solutions of the system (2) are the following functions:

$$Tcu(t) = K_1 \times e^{\lambda_1 t} + K_2 \times e^{\lambda_2 t} + \frac{k \times d}{b \times c - a \times d} I^2$$

$$Tfe(t) = K_3 \times e^{\lambda_1 t} + K_4 \times e^{\lambda_2 t} - \frac{k \times c}{b \times c - a \times d} I^2$$

(4)

where λ_1 and λ_2 are the eigenvalues of the model, i.e. the reciprocals of its time constants, which are obtained as a solution of the quadratic equation:

$$(\lambda - a)(\lambda - d) - b \times c = \lambda^2 - (a + d) \times \lambda + a \times d - b \times c = 0$$

(5)

and K_1, K_2, K_3 and K_4 are values linked to λ_1, λ_2 and to the initial conditions of the model, i.e. to the values of T_{0cu} and T_{0fe} at the start of the transient.

[0034] From the expression Tcu(t) which appears in (4) it is possible to obtain various equations, in the unknown values a,b,c,d and k, once the tripping times t_6, t_3, t_2 e t_1 are assigned, along with other constraints such as the rated values of T_{cu} and T_{fe}. Remembering that T_{sgl} indicates the predefined threshold, the value of which is obtained on the basis of the minimum current value which determines tripping, in asymptotic time, of the protection system, an example of the equation which can be obtained is as follows:

$$Tsgl = K_1 \times e^{\lambda_1 \cdot t_6} + K_2 \times e^{\lambda_2 \cdot t_6} + \frac{k \times d}{b \times c - a \times d} (7.2I_1)^2$$

(6)

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which is nothing other than an indication of the constraint associated with cold tripping, with the current equal to $7.2I_1$, in the time period t_6.

[0035]   The non-linear equations of the type (6) which are obtained upon variation of the tripping time and initial condition in general cannot be solved exactly and are therefore solved using a squared minimum method.

[0036]   By solving the equation of the type (6) the coefficients a,b,c,d and k, and the corresponding initial values for the cold transient, are obtained: by means of (3) the coefficients A,B,C,D and K are then obtained and recorded in suitable tables and will then be used by the device to calculate the status variables of the model. This results in the major advantage of being able to have coefficients which can be used in each case according to the class of the motor without having to adjust physically the protection system, modifying the construction thereof or modifying the settings thereof.

[0037]   An entirely similar method may be used to obtain the coefficients of the thermal model during the cooling phase; in this case the equations are obtained by applying cooling times instead of protection tripping times.

[0038]   With reference to Figure 3, a possible embodiment of the processing means 102 will now be described. The digital signal 2 selected by the acquisition and processing means 102, indicating the highest value of $(I_p)^2$ or $(I_{RMS})^2$, is sent to first multiplier means 20 and multiplied there by the quantity I_n/I_1. The signal 40 obtained is sent to comparison means 21 and compared with two reference values I_{LW} and I_{UP}; for example it is possible to have $I_{LW}=In$ and $I_{UP}=1,1In$. If the signal 40 is between I_{LW} and I_{UP} in order to avoid problems of ripple, a value equal to I_{LW} is assigned to this signal; the output signal 41 is sent to second multiplier means 23.

[0039]   Advantageously, in the protection device according to the invention, it is possible to send the signal 41 to comparator means 22 which compare it with a current value equal to I_{UP} In the case where the value of the signal 41 is greater than I_{UP} the comparator means 22 output a signal indicating the danger of an overload; for example this signal may be used to light up a LED and visually warn an operator of the danger situation.

[0040]   The means 23 multiply the signal 41 by the value of the coefficient K and send the signal obtained 50 to an adder node 24. Two other signals are sent to this node 24: the first signal 42, provided by the value of T_{cu} at the instant t multiplied in fourth multiplier means 25 by the value of the coefficient A; the second signal 45, provided by the value of T_{fe} at the instant t multiplied in fifth multiplier means 26 by the value of the coefficient B. The three signals 42, 45 and 50 are added together in the node 24 so as to obtain at the output the value of Tcu at the instant (t+1). This value is then sent to the comparator means 14 and compared with the threshold value in accordance with that previously described. The values of Tcu(t) and Tfe(t) are moreover sent respectively to the multiplier means 28 and 29 in which they are multiplied, respectively by the values of the coefficients C and D. The two signals are then added to the adder node 30 so as to obtain the value of $T_{fe}(t+1)$. The signals $T_{fe}(t+1)$ and $T_{cu}(t+1)$ are then sent respectively into the blocks 31 and 32 which are memory locations for the calculated values; the values allocated in these blocks in turn form the values at the instant t for the next calculation step.

[0041]   The coefficients A, B, C, D and K are pre-recorded in tables for each class of protection of the motor, according to the method previously described. These tables are also used to record the initial cold values T_{0fe} and T_{0cu} of the status variables which are used in the initial calculation step of the model.

[0042]   The device thus conceived may be subject to numerous modifications and variants all of which fall within the scope of the inventive idea; moreover all the details may be replaced by other technically equivalent elements.

[0043]   Basically, the materials, as well as the dimensions, may be of any kind in accordance with the requirements and the state of the art.

Claims

1. Device for the thermal overload protection of an electric motor connected to a power supply line, said line being provided with sensors for detecting the currents supplying the motor and means for interrupting said currents, characterized in that it comprises:

   - acquisition and processing means 101 which acquire in input, from said detection sensors, analog signals 1 indicating the supply currents of the motor and calculate corresponding digital signals 2;
   - processing means 102 which, depending on said input digital signals 2, calculate the status variables of a thermal model of the motor, said thermal model being based on status equations, the coefficients and initial cold values of the status variables of which are predetermined by means of:

      - definition of the tripping times of the protection system according to the class of motor and its rated supply current;
      - definition of a minimum current which determines tripping of the protection system and definition of the corresponding threshold values of the status variables;
      - calculation of the coefficients of the status equations and initial values of the status variables on the basis of the tripping times and the defined threshold values;

a control unit 103 which compares at least one of said status variables received at its input with a defined threshold value and, if it exceeds the threshold, sends a tripping signal to the interruption means in order to interrupt the power supply of the motor.

2. Device for the thermal overload protection of an electric motor according to Claim 1, characterized in that said status variables consist in a first variable (T_{cu}) indicating the temperature of the copper and a second variable (T_{fe}) indicating the temperature of the iron.

3. Device for the thermal overload protection of an electric motor according to Claim 1, characterized in that said acquisition and processing means 101 comprise conditioning means 5 which condition said input analog signals and supply them to converter means 6 which convert them into corresponding digital signals.

4. Device for the thermal overload protection of an electric motor according to Claim 3, characterized in that the acquisition and processing means 101 comprise first calculating means 8 which receive at their input from the converter means 6 said digital signals and output to first selection means 9 signals indicating the squares of the root mean square values of the supply currents (I_{RMS})^2, said first selection means 9 providing second selection means 11 with the signal indicating the highest value of (I_{RMS})^2.

5. Device for the thermal overload protection of an electric motor according to Claim 3, characterized in that the acquisition and processing means 101 comprise second calculating means 7 which receive at their input from the converter means 6 said digital signals and output to selection and compensation means 10 signals indicating the square of the peak values (I_p)^2 of the supply currents, said selection and compensation means 10 compensating the values received at their input and providing the second selection means 11 with the signal indicating the highest value of (I_p)^2.

6. Device for the thermal overload protection of an electric motor according to Claim 5, characterized in that the second selection means 11 send to the processing means 102 the signal indicating the highest value of (I_{RMS})^2 when (I_{RMS})^2<(I_{lim}), I_{lim} being a predetermined limit value, and send to the processing means 102 the signal indicating the highest value of (I_p)^2 when (I_{RMS})^2>(I_{lim}).

7. Device for the thermal overload protection of an electric motor according to Claim 6, characterized in that the processing means 102 calculate, depending on the current signal received at their input, said variables T_{cu} and T_{fe} and output to comparison means 14 signals indicating calculated values of T_{cu}.

8. Device for the thermal overload protection of an electric motor according to Claim 7, characterized in that the control unit 103 comprises comparison means 14 which compare said signals indicating values of T_{cu} calculated with a defined threshold value and, if they are greater than the threshold, output an alarm signal indicating a thermal overload to command means 15, said command means 15 sending a tripping signal to the interruption means.

9. Method for the thermal overload protection of an electric motor connected to a power supply line, said line being provided with sensors for detecting the currents supplying the motor and means for interrupting said currents, characterized in that it comprises the following steps:

a) acquiring, from said sensors, signals indicating the supply currents of the motor and calculating digital signals corresponding to said analog signals;
b) calculating the status variables of a thermal model of the motor using said digital signals, the thermal model being based on status equations, the coefficients and initial cold values of said variables of which are predetermined in the following manner:

- definition of the tripping times of the protection system according to the class of motor and its rated supply current;
- definition of a minimum current which determines tripping of the protection system and definition of the corresponding threshold values of the status variables;
- calculation of the coefficients of the status equations and initial values of the status variables on the basis of the tripping times and the defined threshold values;

c) comparing at least one of said status variables with a defined threshold value and, if it exceeds said threshold, sending a tripping signal to the interruption means in order to interrupt the power supply of the motor.

10. Method for the thermal overload protection of an electric motor according to Claim 9, characterized in that said step a) comprises:

- conditioning the analog signals received at the input and converting them into corresponding digital signals, said analog signals being sampled with a frequency Fs;
- calculating digital signals indicating the squares of the root mean square values $(I_{RMS})^2$ and the squares of the peak values $(I_p)^2$ of the motor supply currents;
- selecting a signal indicating the highest value of $(I_{RMS})^2$;
- compensating the signals indicating the squares of the peak values (I_p) and selecting the signal indicating the highest value of $(I_p)^2$;
- selecting the signal indicating the highest value of $(I_{RMS})^2$ when $(I_{RMS})^2 < (I_{lim})$, I_{lim} being a predetermined limit value, or the signal indicating the highest value of $(I_p)^2$ when $(I_{RMS})^2 > (I_{lim})$.

11. Method for the thermal overload protection of an electric motor according to Claim 10, characterized in that said step b) comprises calculating, depending on the selected signal indicating the highest value of $(I_{RMS})^2$ or $(I_p)^2$, a system of two difference status equations of the type,

$$Tcu(t + 1) = A \times Tcu(t) + B \times Tfe(t) + K \times I^2$$

$$Tfe(t + 1) = C \times Tcu(t) + D \times Tfe(t) + H \times I^2$$

where A, B, C, D, K, H are predetermined coefficients, and T_{cu} and T_{fe} are status variables indicating the temperatures of the copper and the iron of the motor.

12. Method for the thermal overload protection of an electric motor according to Claim 11, characterized in that said two difference status equations are calculated with calculation frequencies (Fs1, Fs2)>Fs where Fs is not a sub-multiple of Fs1, Fs2.

13. Method for the thermal overload protection of an electric motor according to Claim 9, characterized in that said step c) comprises comparing the value indicating the temperature of the copper T_{cu} with the defined threshold value and, if it exceeds the threshold, sending an alarm signal indicating a thermal overload condition which is present.
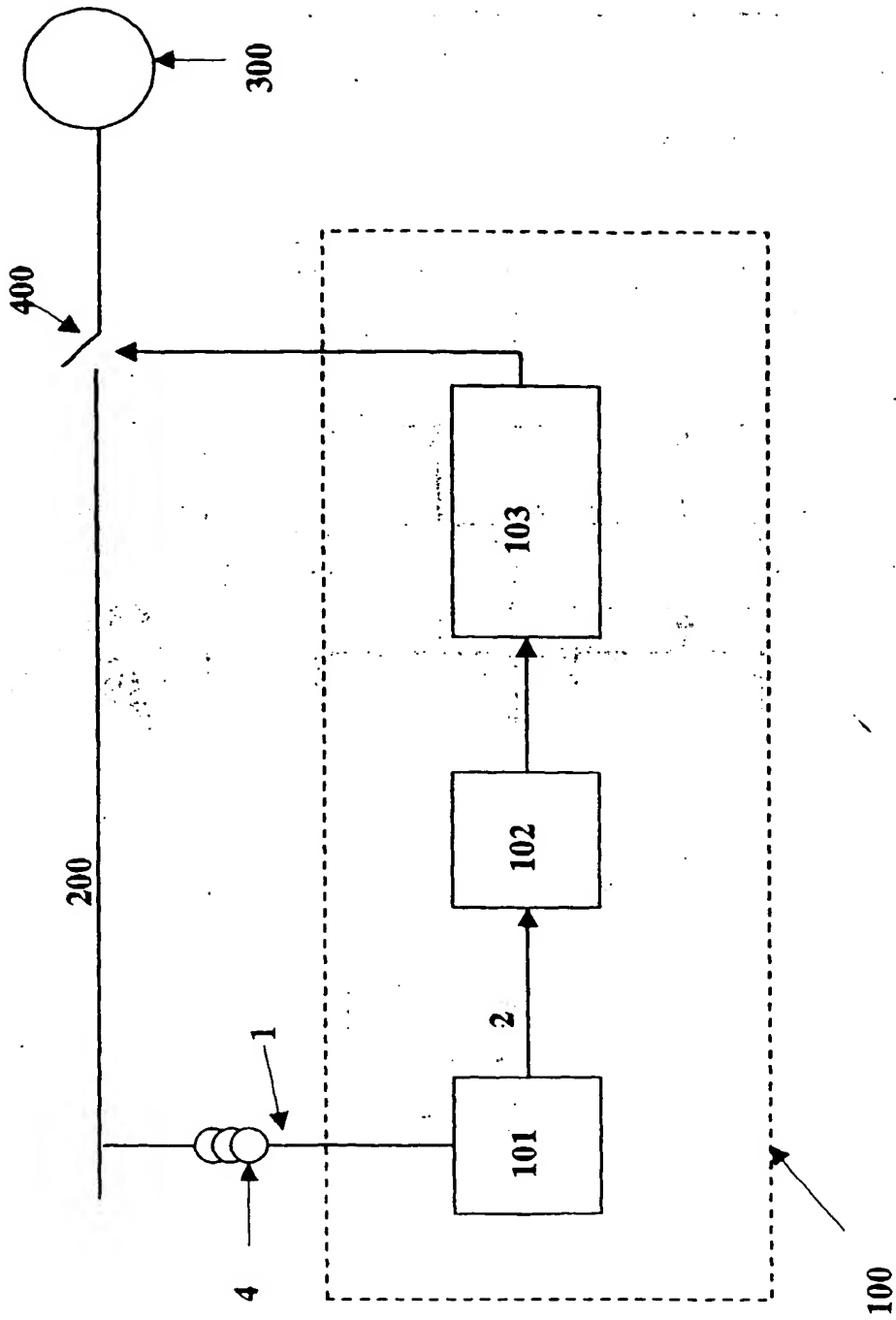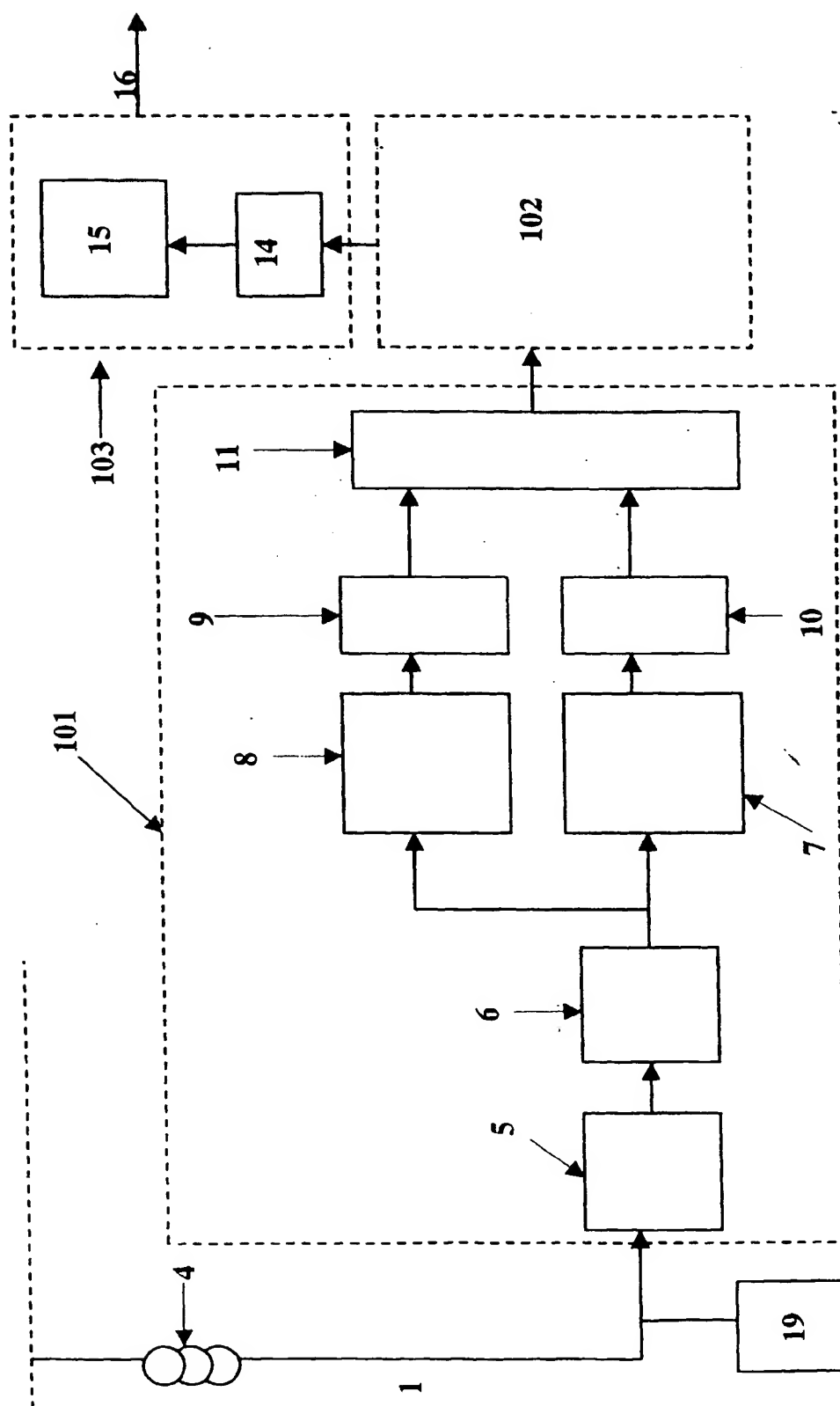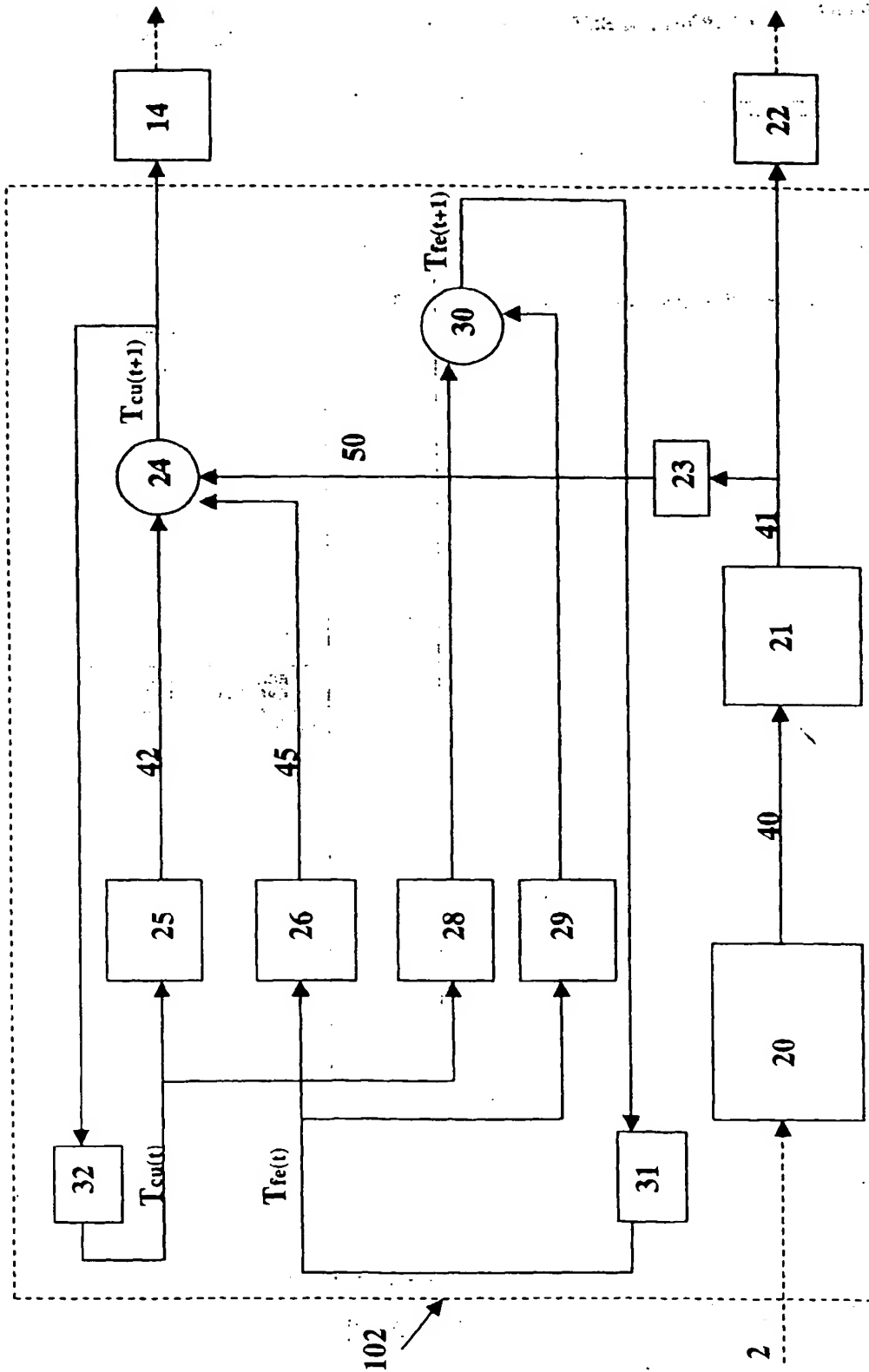
FIG. 1

Fig. 2

FIG. 3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 98 20 3730

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	US 5 684 342 A (INNES MARK EDMUND ET AL) 4 November 1997 * abstract *	1,9	H02H6/00
D,A	US 4 547 826 A (PREMERLANI WILLIAM J) 15 October 1985 * abstract *	1,9	

TECHNICAL FIELDS
SEARCHED (Int.Cl.6)

H02H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	21 April 1999	Salm, R

CATEGORY OF CITED DOCUMENTS

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5684342 A	04-11-1997	NONE	
US 4547826 A	15-10-1985	NONE	

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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